Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

aS21
.A76U66
cop.3

5

~~419~~ 4719944

Quality Maintenance in Truck Shipments of California Strawberries

U.S. DEPT. OF AGRICULTURE
NATL AGRIC. LIBRARY

SEP 25 '80

U.S. Department of Agriculture
Science and Education Administration
Advances in Agricultural Technology • AAT-W-12/July 1980

A copy of this publication is available without charge by writing to the Market Quality and Transportation Research Laboratory, P.O. Box 8143, Fresno, CA 93747.

International Standard Serial Number (ISSN) 0193-3736

Science and Education Administration, Advances in Agricultural Technology Western Series, No. 12, July 1980

Published by Agricultural Research (Western Region), Science and Education Administration, U.S. Department of Agriculture, Oakland, Calif. 94612

ABSTRACT

California strawberries uniformly cooled to 35°F (2°C) before truck shipment had average temperatures of 44°F (7°C) on arrival at east coast markets when pallets were placed against the sidewalls (S/W load) and a lengthwise channel was left along the centerline of the truck. Average arrival temperatures were 40°F (5°C) when the pallets were placed away from the sidewalls and adjacent to one another along the centerline (C/L load). The range of average temperatures at various positions within S/W loads was four times as great (8°F, 4°C) as the range in C/L loads (2°F, 1°C). The average temperature of berries shipped in plastic-covered pallets was about 2°F (1°C) warmer than those in open pallets, regardless of type of load. Initial carbon dioxide (CO_2) levels in the plastic-covered pallets ranged from 4 to 21 percent, and CO_2 levels on arrival at market ranged from 4 to 26 percent. Strawberries shipped in pallets with average CO_2 levels above 10 percent had about one-half as much decay as berries shipped in normal air. Berries shipped below 37°F (3°C) and with CO_2 atmosphere of about 10 percent had a decay incidence of only 5 percent; in those with transit temperatures above 40°F (4°C) and no CO_2, the incidence averaged 33 percent when the berries were held under conditions that simulated retail distribution and consumer use. The loading method did not affect the incidence of cutting and bruising, which averaged 28 percent.

KEYWORDS: Strawberries, transportation, truck, handling, decay, *Botrytis cinerea*, controlled atmosphere, modified atmosphere, physical damage, refrigeration, postharvest losses.

ACKNOWLEDGMENTS

This research was conducted in cooperation with the California Strawberry Advisory Board, Watsonville, Calif.

The following California shippers cooperated by providing test loads of berries to eastern markets:

Deardorff-Jackson Co., Oxnard
Dave Walsh Co., Inc., Oxnard
Mendelson-Zeller Co., Inc., Anaheim
Naturipe Berry Growers, Fullerton and Watsonville
Tenneco West, Oxnard
Well-Pict, Inc., Watsonville

Trade names and the names of commercial companies are used in this publication solely to provide specific information. Mention of a trade name or manufacturer does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture nor an endorsement by the Department over other products not mentioned.

CONTENTS

QUALITY MAINTENANCE IN TRUCK SHIPMENTS OF CALIFORNIA STRAWBERRIES

By J. M. Harvey, C. M. Harris, W. J. Tietjen, and T. Serio[1]

INTRODUCTION

About 327 million pounds of fresh California strawberries were shipped to market in 1979. Almost 90 percent of this fruit was transported by truck and the remainder by air (*1*).[2] A survey of retail and consumer losses in strawberries marketed in the New York metropolitan area indicated that about 5 percent of the berries were culled at the retail level and an additional 18 percent at the consumer level (*3*). About two-thirds of this loss was caused by decay and one-third by mechanical injuries. Postharvest decay losses increase directly as temperatures increase in transit (*6*, *9*, *10*) and decrease with the use of CO_2-enriched atmospheres in transit (*2*, *4*, *5*, *7*, *8*, *10*).

In an effort to improve transit temperatures of strawberries and to reduce cullage, two loading systems were tested in truck shipments from California to New York. The effects of plastic pallet covers on transit temperatures and on atmosphere modification were determined.

METHODS

Details of test shipments of strawberries from various shipping points in California to east coast markets are given in table 1. Paired truck shipments were made with fruit from the same field lot to compare sidewall (S/W) and centerline (C/L) loads (fig. 1). In S/W loads (tests 1, 5, and 8), the pallets of berries were placed tightly against the walls and braced apart with 2- by 4-inch wood blocks along the centerline to form an open lengthwise channel between the two rows of palletized berries. In C/L loads (tests 2, 4, 6, and 7), the pallets of berries were placed tightly together along the centerline of the trailer and were spaced away from the sidewalls. Spacers for the C/L loads were made

---

[1]Harvey is a plant pathologist and Harris is a plant physiologist, U.S. Department of Agriculture (USDA), Science and Education Administration (SEA), Fresno, Calif.; Tietjen is a research assistant USDA, SEA, New Brunswick, N.J.; and Serio is a research technician on contract to the California Strawberry Advisory Board, Watsonville, Calif.

[2]Italic numbers in parentheses refer to Literature Cited, p. 13.

Table 1.--*Truck test shipments of California strawberries to indicated destination, 1977 and 1979*

Test No.	Departure		Arrival		Load type[1]	Thermostat setting		Variety
	Date	Place	Date	Place		°F	°C	
1	4-13-77	Oxnard	4-17	Philadelphia	S/W	35	2	Tioga.
2	4-13-77	--do--	4-17	--do--	C/L	34	1	Do.
3	4-18-79	Anaheim	4-23	New York	(2)	36	2	Tufts.
4	4-18-79	--do--	4-22	--do--	C/L	35	2	Do.
5	5- 2-79	Oxnard	5- 6	--do--	S/W	35	2	Do.
6	5- 3-79	--do--	5- 7	Philadelphia	C/L	34	1	Do.
7	5-30-79	Watsonville	6- 3	New York	C/L	35	2	Aiko.
8	5-30-79	--do--	6- 3	Philadelphia	S/W	35	2	Do.

[1] S/W = loaded against sidewalls; C/L = loaded toward centerline and spaced away from walls.

[2] In this load, the pairs of pallets were alternately placed against the right and left sidewalls of the trailer. This system provided one vertical air channel along one wall at each row of pallets, but no lengthwise channels.

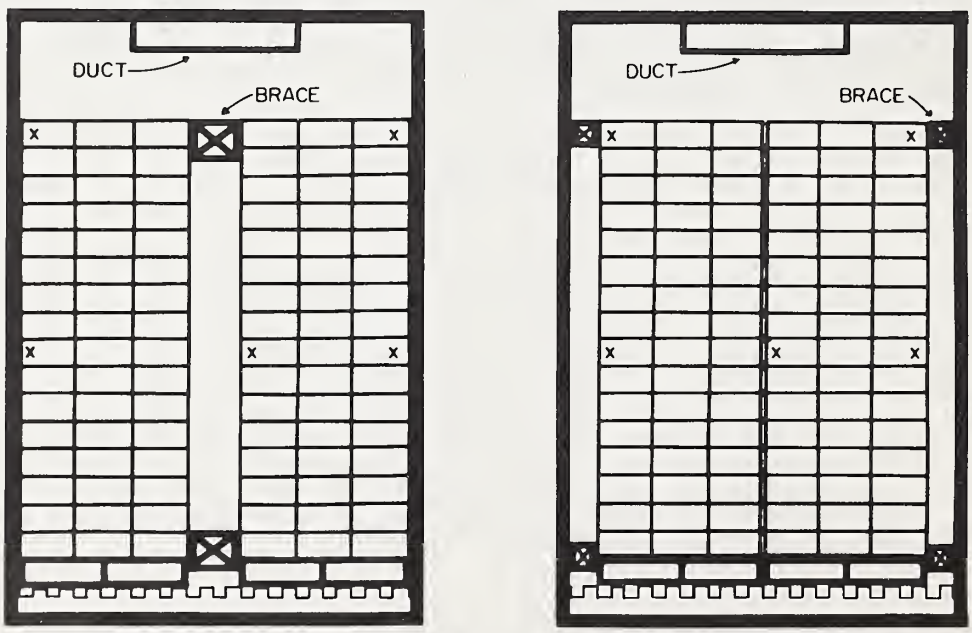

Figure 1.--Cross section of loaded truck at half-length, showing loading pattern for palletized sidewall and centerline loads. Recording thermometers were placed in test trays marked with an "x".

of styrofoam blocks fitted with wire brackets to hold them in place. In one load (test 3), the pairs of pallets were alternately placed against the right and left sidewalls of the trailer. This "staggered" load (S/L) system provided one vertical air channel along one wall at each row of pallets, but no lengthwise channels. All shipments in this series of tests consisted of full loads of berries that had been precooled to about 35°F (2°C) before shipment.

Four test pallets were placed in each load about half way between the front and rear of the trailer. Two of the test pallets were covered with plastic bags that were sealed with tape to a gastight base that had been placed between the pallet and the first layer of strawberry trays (fig. 2). A CO_2-enriched atmosphere was introduced into these units at the shipping point. The other two test pallets were left open, without the plastic cover.

Recording thermometers were calibrated and placed in the test pallets at the positions shown in figure 1. By removing two pint baskets of berries from each test tray of strawberries, sufficient space was provided to fasten a recorder to the bottom of the tray. Ten recorders and test trays were used in each load.

Thermostats on the refrigeration units of the trailers were set at 35° ± 1°F (2° ± 0.5°C).

CO_2 concentrations in the plastic-covered pallets were measured with a portable Orsat-type gas analyzer (Fyrite) at shipping point and again on arrival at the destination market.

Test packages and instruments were recovered at destination markets by personnel of the SEA Eastern Market Pathology Laboratory. Instruments were recalibrated, and berries in the test packages were evaluated for decay, softening, cutting, and bruising. Four baskets of berries from each tray were evaluated on arrival, and three baskets were evaluated at each subsequent examination after holding the fruit for 1 and 2 days at 60°F (16°C).

RESULTS

Temperatures in Transit

Sidewall vs. Centerline Loads

Overall average transit temperatures were less than 2°F (1°C) warmer in S/W than they were in C/L loads (table 2). However, the range of average temperatures of various positions within C/L loads varied by less than 2°F (1°C), while this range in S/W loads varied by almost 8°F (4°C).

The coldest average trip temperature for an individual C/L load was 35°F (2°C), while the warmest was 45°F (7°C). In S/W loads, comparable temperatures were 34°F (1°C) and 50°F (10°C). Temperature extremes, therefore, were greater in S/W than in C/L loads.

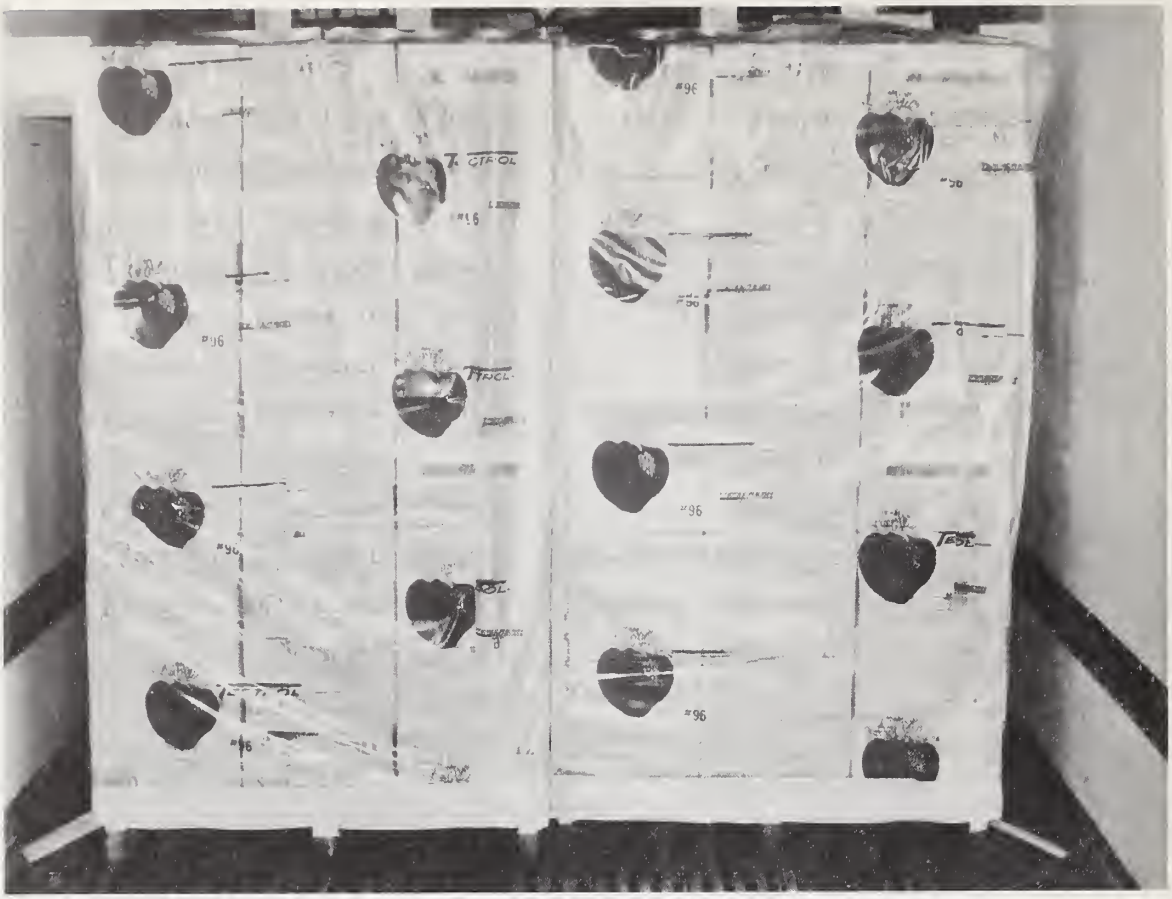

Figure 2.--Plastic-covered pallets of strawberries with CO_2-enriched atmospheres. Pallets placed in a centerline load in a truck.

Table 2.--*Average transit temperatures in centerline and sidewall loads of California strawberries shipped via truck to the New York market*

Load type	Average temperatures in transit							
	Coldest position		Warmest position[1]		Range		Mean	
	°F	°C	°F	°C	°F	°C	°F	°C
Centerline loads (C/L)	39	4	41	5	[2]2	1	39	4
Sidewalls loads(S/W)	37	3	44	7	[2]8	4	41	5

[1]Average temperature of 24 different test packages.
[2]Difference significant at 95-percent level.

Temperatures of all berries placed in C/L loads averaged 35°F (2°C) after precooling and those in S/W loads averaged 34°F (1°C) (fig. 3). After 12 hours of transit, average temperatures of C/L loads were 39°F (4°C) and those of S/W loads were 37°F (3°C); after 24 hours, comparable temperatures were 39°F (4°C) and 38°F (3°C); after 48 hours they were 40°F (4°C) and 43°F (6°C) and at destination they were slightly over 40°F (5°C) and 44°F (7°C), respectively. Average temperatures in C/L loads, therefore, tended to remain almost constant after the initial rise, while those in S/W loads increased with time in transit. In both types of load, however, average temperatures were well above the thermostat setting on the refrigeration unit.

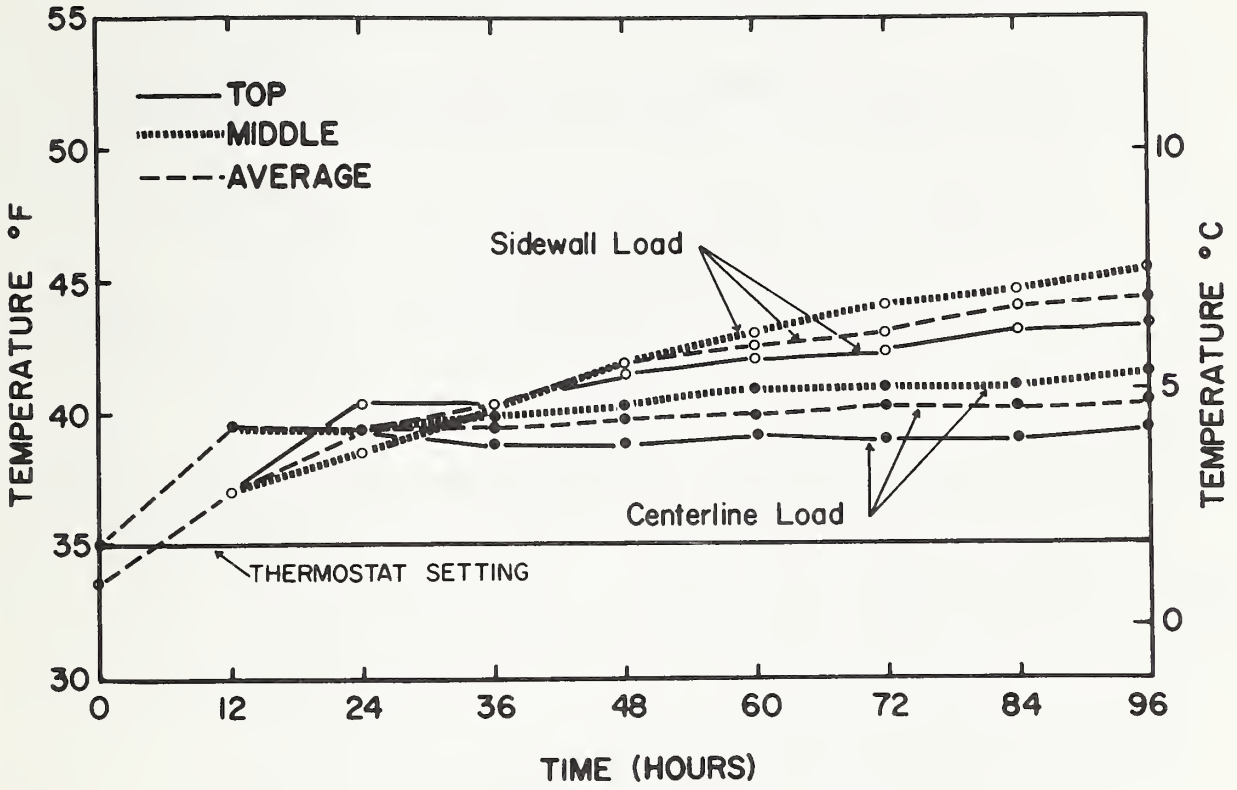

Figure 3.--Average transit temperatures in centerline and sidewall loads of California strawberries shipped by truck to eastern markets.

Only one S/L was included in the test series, so insufficient data were obtained to compare this load pattern with the other two. One-half of the pallets in this type of load, however, would be in contact with the sidewalls, which would contribute to some of the same temperature variation found in all S/W loads.

Plastic-Covered vs. Open Pallets

Berries in plastic-covered pallets had average transit temperatures that were almost 2°F (1°C) higher than those of berries in open pallet loads (table 3). The range in average temperature between the coldest and the warmest positions within plastic-covered pallets and in open pallets was about the same,

4°F (2°C). The lowest average trip temperature measured in an individual plastic-covered pallet was 36°F (2°C) (top layer), while the highest was 48°F (9°C). In the open pallets, the lowest average temperature was 35°F (2°C) and the highest was 44°F (7°C).

Berries had an average temperature of 35°F (2°C) after precooling (fig. 4). Those in film-covered pallets had an average temperature of 40°F (4°C) after 12 hours in transit and of 43°F (6°C) on arrival at destination (96 hours). Comparable temperatures of berries in open pallets were 38°F (3°C) after 12 hours and 41°F (5°C) on arrival.

Table 3.--*Average transit temperatures in plastic-covered and open pallets of California strawberries shipped via truck to the New York market*

Pallet type	Average temperatures in transit (excluding first 12 hours)							
	Coldest position[1]		Warmest position		Range		Mean	
	°F	°C	°F	°C	°F	°C	°F	°C
Plastic covered	39	4	43	6	4	2	[2]41	5
Open	37	3	41	5	4	2	[2]39	4

[1] Average temperature of 16 test packages.
[2] Difference significant at 95-percent level.

Modified Atmospheres in Transit

At shipping point, the average concentration of carbon dioxide in 16 film-covered pallets was 13 percent, but concentrations among individual pallets ranged from 4 to 21 percent (table 4). At destination, the concentrations averaged 10 percent, but ranged from 4 to 26 percent. Overall, the CO_2 level averaged 11 percent. Generally, pallets that had a high level of CO_2 at shipping point, had a high level at destination, unless the film was torn during loading or unloading. A few pallets had higher levels of CO_2 at destination than at origin, due to the additional CO_2 that accumulated from respiration of the fruit.

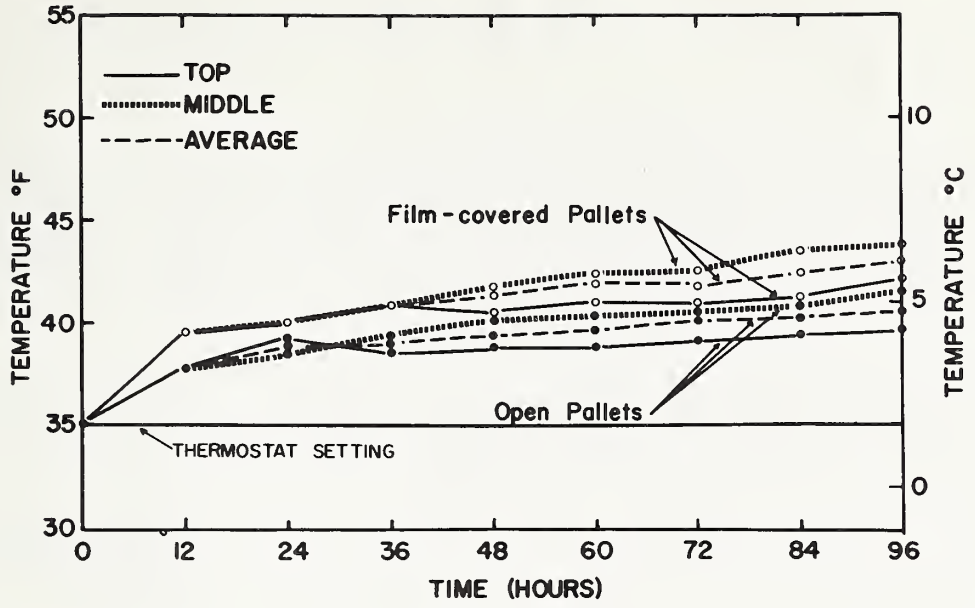

Figure 4.--Average transit temperatures in film-covered and open pallet loads of California strawberries shipped by truck to eastern markets.

Table 4.--*Average concentrations of CO_2 in plastic-covered pallets at shipping points in California and on arrival at eastern markets*

Test No.	Average CO_2 concentration at indicated place				
	Shipping point		Arrival		
	Pallet No. 1	Pallet No. 2	Pallet No. 1	Pallet No. 2	Average
	Percent				
1	8	13	8	10	10
2	12	17	11	5	11
3	9	8	4	4	6
4	20	17	9	5	13
5	21	12	7	6	11
6	21	19	26	19	21
7	14	14	8	16	13
8	4	4	9	8	6
Average	13		10		11

Losses from Decay

Decay vs. Type of Load

The average percentage of decayed berries did not differ significantly in respect to load type (table 5), although slightly less decay developed in berries from the C/L loads than in those from the S/W loads. The difference was greatest (8 percent) (but not statistically significant) when the fruit was examined after 2 days at 60°F (16°C). Most decay was caused by the fungus *Botrytis cinerea* Pers. ex Fr.

Table 5.--*Average incidence of decay in California strawberries shipped in centerline- or sidewall-loaded trucks to eastern markets*

Load type	Incidence of decayed berries			
	On arrival	After 1 day at 60°F	After 2 days at 60°F	Average
	Percent			
Centerline (C/L)	2	3	14	6
Sidewall load (S/W)	1	4	22	9

Decay vs. Modified Atmosphere

Differences in decay due to atmosphere modification were negligible on arrival, but the differences became progressively greater after 1 and 2 days at 60°F (16°C) (table 6). The difference in decay of berries shipped in plastic-covered and open pallets was not significant when all test shipments were compared. However, when only those shipments in which the CO_2 level was above 10 percent in the plastic covered pallets were compared with the open pallets, decay after 2 days at 60°F (16°C) was significantly lower in covered than in open pallets.

Decay vs. Temperature vs. Modified Atmosphere

The interacting effects of transit temperatures and atmosphere modification on decay are shown in table 7. After holding 2 days at 60°F (16°C) at the market, decay percentages were lowest (5 percent) in berries from trays with transit temperatures that were at 37°F (3°C) or below and that were shipped in covered pallets with 10 percent or more CO_2 on arrival. Decay percentages were largest (33 percent) when transit temperatures were at 40°F (4°C) or above and no atmosphere modification was provided. After 2 days at 60°F (16°C), less decay developed in berries that had been shipped at temperatures above 40°F (4°C) when the CO_2 level was above 10 percent (14 to 17 percent decay) than when no atmosphere modification was provided (33 percent decay in open pallets).

Table 6.--*Average incidence of decay in California strawberries in plastic-covered and in open pallets shipped via truck to eastern markets*

Pallet type and atmosphere	Incidence of decayed berries			
	On arrival	After 1 day at 60°F	After 2 days at 60°F	Average
	Percent			
All test shipments:				
Plastic covered	2	6	[2]2	10
Open	3	8	[2]8	13
Test shipments with CO_2 above 10 percent:[1]				
Plastic covered	2	[2]4	[2]14	[2]6
Open	2	[2]7	[2]24	[2]11

[1]In plastic-covered pallets only.
[2]Difference significant at 90-percent level.

Table 7.--*Incidence of decay in California strawberries shipped by truck at various average transit temperatures with and without CO_2 atmospheres*

Average transit temperatures		Incidence of decay 2 days after arrival			
		All CO_2 treatments	CO_2 over 10 percent	Open pallet	Average
		Percent			
°F	*°C*				
42 and above	5.5	27	14	33	23
40 to 41	4.5-5.0	25	17	33	25
38 to 39	3.5-4.0	21	10	29	20
37 and below	3.0	6	5	24	15

The overall effect of CO_2 concentrations in transit on decay of berries held for 2 days at 60°F (16°C) is shown in figure 5. The incidence of decay decreased as the level of CO_2 in the atmosphere increased (within the limits indicated in table 4).

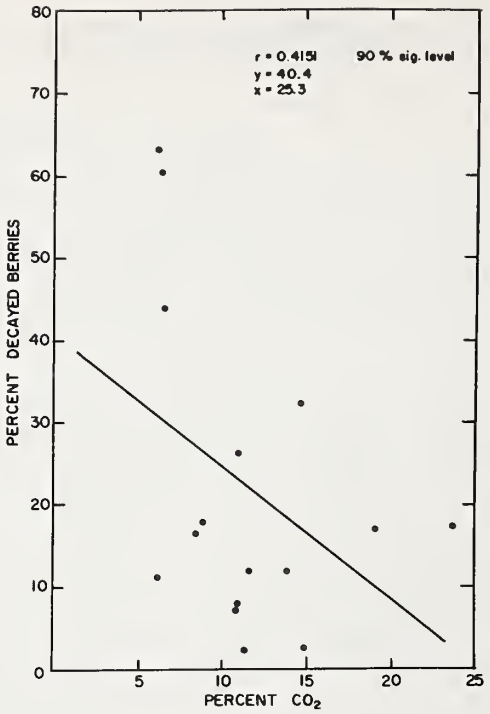

Figure 5.--Effect of CO_2 concentration in transit on incidence of decay of California strawberries shipped by truck to eastern markets.

Cuts and Bruises

Cuts and bruises did not differ significantly in berries shipped in C/L or S/W loads (table 8). Slightly more cuts and bruises occurred in berries shipped in plastic covers (29 percent) than in those shipped in open pallets (26 percent), but the difference was not great enough to be significant. However, the overall average of almost 28 percent cut and bruised berries was very high and suggests that an effort should be made to reduce such losses.

Table 8.--*Average incidence of cuts and bruises in California strawberries shipped in centerline- or sidewall-loaded trucks to eastern markets*

Load type	Incidence of cut and bruised berries		
	Plastic-covered pallets	Open pallets	Average
	Percent		
Centerline load (C/L)	29	27	28
Sidewall load (S/W)	30	25	28
Average	29	26	28

DISCUSSION

Precooling

Berries used in the eight test loads had an average temperature of 35°F (2°C) when the trucks were loaded, which indicated the effectiveness of most precooling facilities in California.

Transit Temperatures vs. Loading Pattern

Transit temperatures were much more uniform in C/L than in S/W loads. The range of average temperatures at various positions within the loads was one-fourth as great in C/L loads (2°F) as in S/W loads (8°F) (1° vs. 4°C). Average temperatures at destination markets were about 40°F (4°C) in C/L loads and 44°F (7°C) in S/W loads. Although thermostats were set at 35° ± 1°F (2° ± 0.5°C), transit temperatures in both types of loads were well above those considered optimum for strawberries and were well above the desirable temperatures achieved during precooling. The high temperatures on arrival suggest the need to recalibrate thermostats, improve insulation, increase the capacity of refrigeration systems, and/or operate the unit long enough before loading to cool down the trailer.

Transit Temperatures vs. Plastic Pallet Covers

Berries shipped in plastic-covered pallets averaged about 2°F (1°C) warmer (41°F, 5°C) than those in open pallets (39°F, 4°C). The highest average trip temperature in an individual plastic-covered pallet was 52°F (11°C) and in an open pallet was 47°F (8°C). Although the use of the plastic covers increased the average load temperatures and extended the range of temperatures within loads, in comparison to open-pallet loads of berries, less decay developed in berries shipped in covered pallets when CO_2 atmospheres were maintained (see following paragraphs).

Atmosphere Modification in Plastic-Covered Pallets

The variability in CO_2 concentrations after treatment of individual plastic-covered pallets was high (4 to 26 percent), although the overall average CO_2 concentrations was 11 percent. There is an obvious need to improve the techniques for administering the gas to pallet loads of berries and for maintaining an effective concentration of the gas in transit.

Decay vs. Atmosphere Modification vs. Temperature

Overall decay was slightly less in berries shipped in plastic-covered pallet loads than in open pallet loads. Decay reduction was greatest when CO_2 levels in pallet loads were maintained at or above 10 percent during transit.

At 13 percent CO_2, decay was reduced to about one-half that in open pallets. A combination of low transit temperatures (37°F (3°C) and below) and CO_2-enriched atmosphere (over 10 percent) resulted in the least amount of decay (5 percent) when berries were held for simulated consumer use. Temperatures above 40°F (4°C) without atmosphere modification resulted in the highest amount of decay (33 percent). Prolonged exposure to excessive CO_2 atmospheres (20 to 30 percent or more) may impair the flavor of strawberries and should be avoided (*2*, *5*).

Cuts and Bruises

Neither type of loading method (C/L vs. S/W) nor the use of plastic pallet covers had a significant effect on the percentage of cut and bruised berries; however, the overall average of 28 percent cut and bruised berries suggests a need to improve harvesting, packaging, or handling methods. All of the test pallets were positioned near the one-half length of the truck, so they were not over the rear wheels where one might expect even more damage from vibration.

CONCLUSIONS

Although California strawberries are customarily precooled to an acceptable temperature (35°F, 2°C) before loading them into truck trailers, they generally arrive at destination markets at temperatures that are 5° to 9°F (3° to 5°C) above their initial temperature and 8° to 12°F (4° to 7°C) above the optimum temperature for strawberries (32°F, 0°C). These higher-than-optimum temperatures contribute to increased loss of quality, increased incidence of decay, and reduced shelf life.

The maintenance of near-optimum transit temperatures in truck trailers may require better calibration of truck thermostats, heavier insulation of trailers, and/or the use of refrigeration units with increased capacity. In the absence of these improvements, trailers should be thoroughly precooled before loading and a C/L loading pattern should be used to improve the uniformity of berry temperatures in transit. Since berries shipped in plastic-covered pallets have average transit temperatures that are about 2°F (1°C) warmer than those shipped in open pallets, it may be feasible to lower thermostat settings slightly when full loads of berries are shipped in the plastic covers.

The supplementary use of CO_2-enriched atmospheres (13 to 20 percent) also may partially compensate for the lack of optimum temperatures in transit. Such CO_2 atmospheres have reduced decay losses to about one-half of those in open pallets. Procedures for applying CO_2 to the plastic-covered pallets should be carefully monitored to assure that adequate concentrations of the gas are administered and maintained in transit.

Losses from cutting and bruising were not affected by the method of loading (C/L vs. S/W) or by the use of pallet covers. The high incidence of damage (28 percent) suggests a need for improved methods of handling berries during harvest and prior to shipment.

LITERATURE CITED

(1) Anonymous.
1980. California strawberry report. Federal-State Market News Service 66(1):1

(2) Brooks, C., E. V. Miller, C. O. Bratley, and others.
1932. Effect of solid gaseous carbon dioxide upon transit diseases of certain fruits and vegetables. U.S. Department of Agriculture, Technical Bulletin No. 318, 60 p.

(3) Ceponis, M. J., and J. E. Butterfield.
1973. The nature and extent of retail and consumer losses in apples, oranges, lettuce, peaches, strawberries, and potatoes marketed in greater New York. U.S. Department of Agriculture, Marketing Research Report No. 996, 23 p.

(4) Couey, H. Melvin, and John M. Wells.
1970. Low-oxygen or high-carbon dioxide atmospheres to control post-harvest decay of strawberries. Phytopathology 60:47-49.

(5) Harris, C. M., and J. M. Harvey.
1973. Quality and decay of California strawberries stored in CO_2-enriched atmospheres. Plant Disease Reporter 57(1):44-46.

(6) Harvey, J. M., H. M. Couey, C. M. Harris, and F. M. Porter.
1965. Air transport of California strawberries: factors affecting market quality in summer shipments - 1965. U.S. Department of Agriculture, Marketing Research Report No. 751, 12 p.

(7) _____ H. M. Couey, C. M. Harris, and F. M. Porter.
1966. Air transport of California strawberries: factors affecting market quality in spring shipments - 1966. U.S. Department of Agriculture, Marketing Research Report No. 774, 9 p.

(8) _____ C. M. Harris, and F. M. Porter.
1971. Air transport of California strawberries: pallet covers to maintain modified atmospheres and reduce market losses. U.S. Department of Agriculture, Marketing Research Report No. 920, 10 p.

(9) Maxie, E. C., F. G. Mitchell, and Arthur Greathead.
1959. Studies on strawberry quality. California Agriculture 13(2):11, 16.

(10) Wells, J. M.
1970. Modified atmosphere, chemical, and heat treatments to control postharvest decay of California strawberries. Plant Disease Reporter 54:431-434.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1980 695-724/274

U. S. DEPARTMENT OF AGRICULTURE
SCIENCE and EDUCATION ADMINISTRATION
WESTERN REGION
1333 BROADWAY, SUITE 400
OAKLAND, CALIFORNIA 94612

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. DEPARTMENT OF
AGRICULTURE
AGR 101

PRINTED MATTER

Return the mailing label(s) to above address if:

- ☐ Your name or address is wrong (indicate corrections, including ZIP).
- ☐ You receive duplicate copies (include labels from all copies received).
- ☐ You do NOT wish to continue receiving this technical series.